Update on TacAir-Soar

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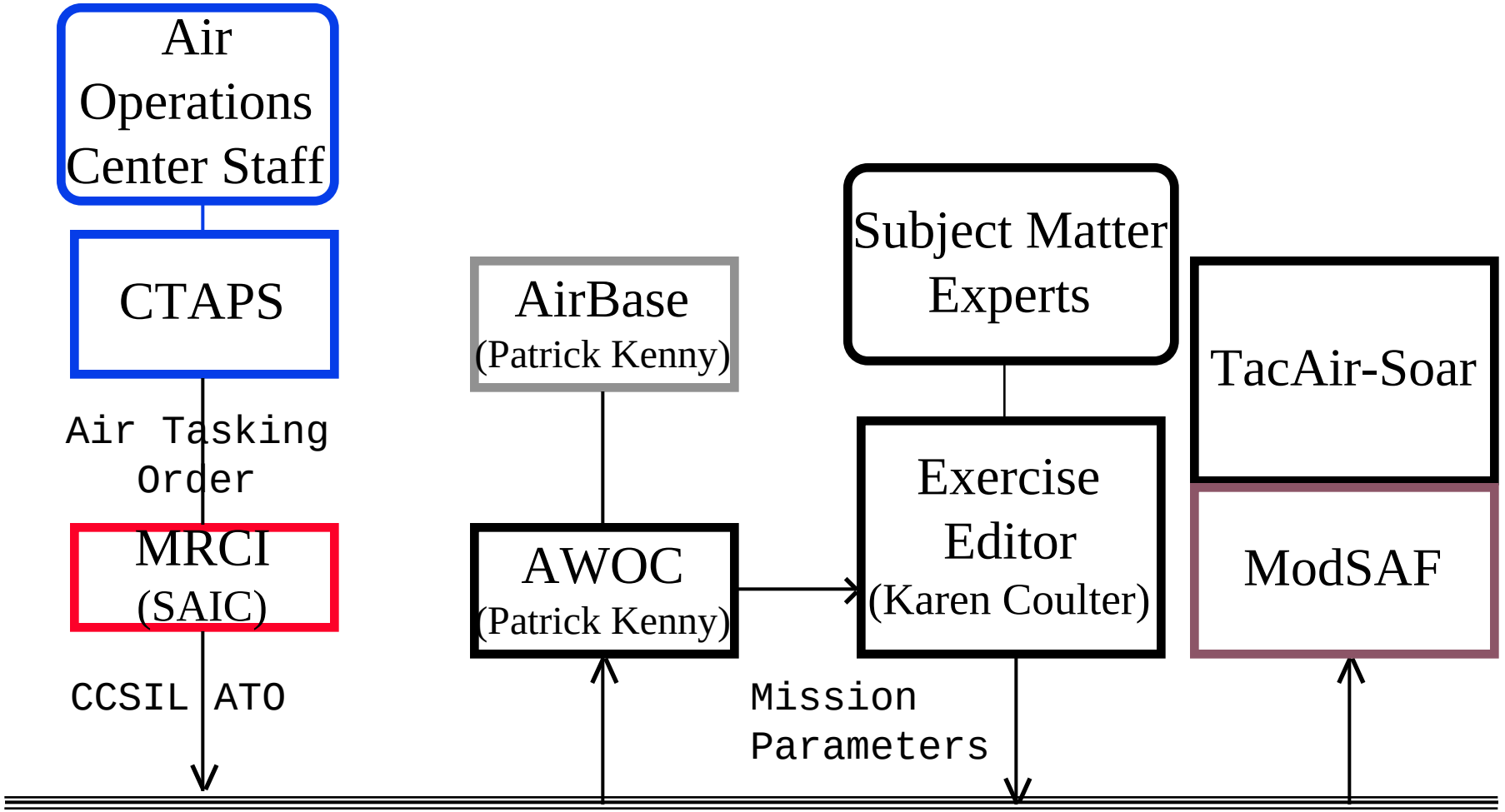
Project Goals

- Create synthetic pilots whose behavior is comparable to humans for theater-level fixed wing aircraft missions.
- Embed synthetic pilots in a system that supports training using realistic command and control.
  - Missions are generated using standard military software systems.
  - Communication with commanders during missions obey standard doctrine.
  - Results of missions (BackTel) are reported through appropriate channels.

Overall System Layout



Components

- Automated Wing Operations Center
  - Picks up mission data from air tasking order.
  - Placeholder for automated mission planning.
  - Collects and forwards BackTelfrom planes.
- Exercise Editor
  - Allows SME's to refine mission data.
  - Forces SME's to plan missions.
- Together these help embed TacAir-Soar in existing command structure.

Agent Overview

- Covers all theater-level FWA missions.
  - Defensive counter air, offensive counter air, close air support, strategic attack, suppression of enemy air defense, escorts, forward air controllers, airborne early warning, tankers, intelligence.
- Covers all aspects of missions.
  - Planning, takeoff, fueling, communication, landing, ...
- Involves large number of planes flying together.
  - Up to thirty planes for some missions.
- Grown from 3,700 rules to 4,800 rules in last year.
  - New missions, communications, sensors, and weapons.
  - > 1,500 sets of additions and modifications.
- Code rewritten to improve efficiency, flexibility, ...

Agent Structure

- Maintained same structure:
  - Hierarchical decomposition of missions and tasks into suboperators.
    - Over 400 operators.
  - Opportunistic operators jump in as necessary.
    - Communication, situational awareness, ...
- Significant efficiency improvements through architectural restrictions:
  - Removed all chunking and justification overhead.
    - Restricted to only o-supported results, fast o-support: Doug P.
  - Required few changes (< 5 rules modified).

Agent Data

- Average run: 1-2 hours.
- # of agents can run on one machine at a time:
  - 24 on a P6 (Pentium Pro 200 MHz with 256M b)
  - Averaging 4 decisions / seconds for route flying.
  - Not recommended in general - probably 10-12.
- # of agents in the air at a time.
  - Have had over 20 machines with > 80 total agents.

Agent Data: Benign

- Take-off, route-flying, racetrack
  - 20 Soar planes running on one machine:
  - ~25 minutes elapsed real time
  - Data for one agent:
    - 44 sec. kernal time, 70 sec. total cpu time
    - 8,000 Decisions: 5.5 msec / decision
    - 2,693 Elaboration cycles
    - 8,405 Production firings: 5.2 msec / pf
    - 76,4936 WM changes: .044 msec / wm change
  - During one 2000 decision stretch of route flying, only fired 1 production.

Agent Data: Hostile

- Take-off, route-flying, intercept:
  - 3 Soar planes + 1 ModSAF
  - ~25 minutes elapsed real time
  - Data for lead Soar plane:
    - 50 sec. kernal time, 60 sec. total cpu time
    - 20,000 Decisions: 2.5 msec / decision
    - 3,623 Elaboration cycles
    - 7,317 Production firings
    - 354,333 WM changes

Demonstrations, Tests, Etc.

- Participated in many tests (CT1-4, FST-1).
  - These evaluate behavior, connectivity, ease of use.
  - To date, we have never had a “failed” test.
  - ! At most recent test, SME’s defined and ran all missions.
- Remaining tests:
  - Full-System-Test 2-4.
  - One test a month through September
  - STOW-97: October, 1997.
    - Very big deal. Involves simulations of all services.
    - 200 aircraft in flight at a time.
    - Combined with United Endeavor-98, a real training exercise.

Coal and Nuggets

- **Coal**
  - Development is very labor intensive.
  - We've emphasized development over research.
- **Nuggets**
  - Still on track -- Soar has proven itself for a real-world, real-time, complex application.
    - No longer need to defend this approach.
    - Accepted in DOD simulation community as highest-fidelity.
  - Pilots continue to say that they are "very impressed".
  - Embedded in existing command and control structure.
  - Lots of future research and applications.

Future Work

- Follow on support of STOW-97.
- Training of AWACS Crew: Warrior Flag.
- Expanded missions: Joint Search and Rescue.
- Fielding for training in USAF.
  - Using manned simulators at all USAF bases. >$100M.
- Cognitive Modeling
  - Modeling effects of fatigue on performance.
  - Modeling time to perform subparts of total missions.
- Enough future applied work to warrant the creation of Soar Technology, Inc.